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**ENHANCED WEED CONTROL FOR SASKATCHEWAN
CROP PRODUCERS**

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Final Report

ADF Project # 20030520

**Enhanced Weed Control for Saskatchewan Crop Producers
April 1, 2004 – March 31, 2009**

**F.A. Holm and K.L. Sapsford
Dept. of Plant Sciences
University of Saskatchewan**

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(a) Abstract/Summary

This grant provides the funding to support the senior research technician position in the herbicide research program in the Department of Plant Sciences at the University of Saskatchewan. During the course of the funding period, 258 field trials were conducted to address a wide range of weed management issues in cereal, oilseed, pulse and special crops. These trials involved 3,814 individual treatments. The information obtained from these trials is utilized in a number of ways. In some cases, the data are used to support the registration of new active ingredients but, more often, they are used to support modifications of labels of existing products (addition of new weeds and / or crops, modification of rate structures, re-cropping guidelines and product formulations. In the majority of cases, the data are made public but there are some instances where the data remain confidential. These latter cases usually involve trials to evaluate new formulations of existing products. Given the number of trials conducted, it is not possible to summarize the results in this abstract. Results of the research are made available through a variety of mechanisms. An annual Research report is produced that includes the results of all of the non-confidential trials conducted during the year. This is distributed to all organizations that fund the program, a number of Saskatchewan Ministry of Agriculture extension staff and several industry agronomists. Approximately 80 copies are distributed each year. Ken Sapsford and Rick Holm both are involved in extending the research results and, over the past 5 years, we have: participated in 18 extension meetings and 19 field days/tours; made 42 contributions to research conferences and workshops; contributed to 12 manuscripts published in refereed scientific journals; contributed to 6 technical reports. The results of our work have been mentioned in 33 articles in the farm media. During the five years of this project 24 different organizations have provided financial support totaling just over \$1.4 million. Of this amount, 39% has been obtained from government sources and 61% from industry (herbicide manufacturers and producer groups).

(b) Introduction

The purpose of this grant was to provide core technical support to the weed research program in the department of Plant Sciences and the Crop Development Centre at the University of Saskatchewan. This core support has been crucial to maintaining a strong program with the ability to attract external funding required to meet the program's objective which is to "support crop diversification and the profitability of field and special crop production through the development of improved weed control methods".

(c) Methods

Four replicate experiments of appropriate design (RCBD, Split-plot, Split, split-plot) are carried out using standard weed control research protocols for small-plot herbicide trials. Individual experiments are designed and analyzed using Agricultural Research Manager software (Gylling Data Management Inc, Brookings, SD). Visual assessment of weed control and crop injury is carried out using the guidelines established by the Canadian Weed Science Society. Plots are seeded with a 10-run no-till plot seeder. Herbicides are

applied with a custom-built small-plot sprayer equipped with 12 two m wide booms with a nozzle spacing of 50 cm and equipped with air-induction, low drift nozzles typical of those used on most field crop sprayers. Grain yield is determined by harvesting a 1.3 m wide strip from the centre of each plot using a Hege self-propelled small-plot combine. Grain samples are dried to a standard moisture content and are cleaned prior to weighing for yield determination. Residue trials conducted for the AAFC/PMRA Minor Use Registration Program are conducted according to GLP protocols and Canadian Standards Association approved Standard Operating Procedures and are subject to external quality assurance audits.

The bulk of our work is conducted at the Kernen Crop Research Farm (KCRF) but we also do considerable work at the Goodale Research Farm (GRF) and on land owned by the Saskatchewan Pulse Growers (SPG) just east of the GRF. A brief description of the soil properties at these three locations is as follows:

Kernen Crop Research Farm

Primary Plot Area - Block E3

Sutherland heavy clay - 12% sand, 28% silt, 60% clay, 4.0% Organic matter, pH 7.6

Goodale Research Farm

Weed Control Research - W1-W10

Bradwell fine sandy loam - 37% sand, 40% silt, 23% clay, 1.9% Organic matter, pH 7.0

Sask Pulse Growers Land

Elstow Orthic Dark Brown Loam - %Sand 20 % Silt 49 % Clay 31, 5.0% Organic Matter, pH 7.2, CEC 15.7

When necessary, we also rent land from producers and conduct trials at locations provided by collaborators. In the reporting period we have conducted trials in farm fields at Colonsay, Elstow, Elrose, Meath Park, Floral and on the Investigation Field on the University campus.

The numbers of trials conducted and the number of treatments evaluated during the funding period (2004 through 2008 growing seasons) are shown in the following table:

(d) Results

Given the large number of trials conducted and the very high number of treatments evaluated, it is not feasible to provide a detailed report normally provided for an ADF funded research project which typically has a much narrower focus. Copies of detailed reports of all non-confidential trials that have been provided annually and are enclosed with this report. Electronic copies or additional hard copies can be provided if required. Results and Conclusions for major projects are presented in Section (e).

(e) Conclusions/Recommendations

User Requested Minor Use Label Expansion (URMULE) Program

For several years our program has supported the effort to obtain URMULE registration of herbicides for use in special crops and this continued to be a significant priority from 2004 through 2008. We collaborate very closely with the AAFC URMULE program at Scott, SK. In the effort to make additional weed control options available to Saskatchewan crop producers. In addition, our program has supported the provincial minor use co-ordinator of the Ministry of Agriculture by participating in both the Saskatchewan and National priority setting meetings annually. The cost of participating in these meetings has been covered by externally generated funds. During the reporting period, the following issues were addressed;

- Fall application of florasulam prior to seeding chickpea. Resulted in unacceptable crop injury.
- Fall application of florasulam prior to seeding lentil. Caused low levels of injury at registered rates, unacceptable injury at higher rates.
- Tolerance of Canaryseed to pre-seed and pre-emergence application of PrePass. The crop showed good tolerance.
- Efficacy of isoxaflutole in chickpea. A large number of trials were conducted over several years to evaluate this compound for weed control in chickpea. The herbicide was applied alone and in combination with sulfentrazone. In both cases, crop tolerance was excellent. Combined with sulfentrazone, a wide spectrum of broadleaved weeds were controlled. A number of re-cropping trials were also conducted to determine levels of herbicide persistence and safe rotational crop options. Unfortunately, the manufacturer of isoxaflutole chose not to commercialize the product in western Canada and so the opportunity for a URMULE registration was lost.
- Puma Super use on Canaryseed. In our trials, the crop was severely injured by this product. This was consistent with the experience at other test locations.

- Assure II on chickpea. Excellent crop tolerance. The product is registered for use.
- Tolerance of flax to vinegar. Rates of vinegar high enough to control wild mustard caused severe crop injury. Other broadleaved weeds (stinkweed, wild buckwheat, redroot pigweed) were not controlled.
- Tolerance of flax to sulfentrazone. Several trials were conducted to assess efficacy and crop tolerance. Good crop tolerance at 140 g ai/ha (suggested label rate) but 280 g ai/ha causes some crop damage. A submission to register has been submitted to PMRA.
- Tolerance of tame mustard to sulfentrazone. This herbicide is weak on wild mustard so its potential for use as a herbicide in tame mustard was investigated. Unfortunately, rates high enough to control important weeds also caused significant crop injury. Juncea mustard appeared to be more sensitive than yellow and oriental types.
- Herbicide screening for hemp. Assure, Poast, Avadex BW and Everest appeared to be safe to use on the crop although Everest caused some initial injury. Pardner also causes significant early injury but the plants recover and yield was not affected. Lontrel appears to be safe on the crop at 302 g ai/ha. Muster caused significant crop injury.
- Tolerance of Andante and Cutlass yellow mustard to pre-e and post-e herbicides. Muster at 15 g ai/ha and sulfentrazone at 140 g ai/ha injured yellow mustard. Lontrel and Accord at 2X label rates were safe to use on the crop as was sulfentrazone at 70 g ai/ha. Unfortunately, this rate of sulfentrazone does not adequately control many important weeds.
- Fall applied IMI herbicides for weed control in chickpea. This is a revival of considerable work that we did in the 1990's which showed good potential for fall application of reduced rates of Pursuit for broadleaved weed control in this crop. The manufacturer has shown no interest in pursuing a registration but the effort to obtain a URMULE registration continues. In fall 2006, imazethapyr (Pursuit) was applied at 12.5, 16.7 and 33 g ai/ha imazamox (Solo) was applied at 10, 15 and 20 g ai/ha prior to seeding Desi chickpea in 2007. Conclusions: In 2007, there was no injury to chickpea with any of the treatments. Stinkweed was controlled with Pursuit @ 33 g ai/ha and suppressed with Pursuit @ 16.7 g ai/ha. Wild buckwheat was controlled with all three rates of Pursuit. Solo at 10, 15 and 20 g ai/ha did not control any of the broadleaf weeds in this trial. In the fall of 2007, Pursuit was applied alone at 12.5, 16.7 and 33 g ai/ha (25%, 33% and 66% of recommended rate, respectively). These rates were also applied in combination with ethalfluralin at 1400 g ai/ha. During the 2008 growing season, redroot pigweed was controlled >95% with all treatments that included Pursuit @ 12.5 g

ai/ha or greater. There was no advantage to combining Edge with Pursuit. Wild buckwheat control was variable and suppression or control of this weed was achieved only with treatments that included Pursuit @ 12.5 g ai/ha or greater. Cleavers was controlled >98% with Pursuit @ 33 g ai/ha and with treatments that included Edge @ 1400 g ai/ha plus Pursuit @ 12.5, 16.7 and 33 g ai/ha. There was no visual injury to chickpea from any of the treatments. All treatments that included Edge @ 1400 g ai/ha + Pursuit @ all rates yielded significantly greater than the Edge alone or Pursuit alone.

This trial was repeated on lentil in 2008. Control of redroot pigweed and stinkweed was >90% with all treatments that included Pursuit @ 12.5 g ai/ha or greater. Wild buckwheat control was variable and all treatments suppressed or controlled wild buckwheat. There was no visual injury to lentil from any of the treatments. All treatments that included Edge @ 1400 g ai/ha resulted in higher yields than treatments that did not include Edge, but not all yield increases were statistically significant.

Consistent with our findings from earlier work, it seems that fall application of a low rate of Pursuit will provide adequate control of a number of troublesome broadleaved weeds without injuring chickpea or lentil crops. An obvious weakness of such a treatment, however, is the lack of control of Group 2 resistant kochia.

- Lontrel for yellow mustard. This herbicide appears to be safe on the crop at up to 410 g ai/ha when applied at the 2 – 6 leaf stage. Higher rates can significantly increase the time to maturity.
- Assert, Lontrel and Centurion on Prairie Carnation. Assert at 500 and 1000 g ai/ha; Lontrel at 75 and 150 g ai/ha and combinations of Assert + Lontrel at 500 + 75 and 1000 + 150 g ai/ha were applied post emergent to Prairie Carnation under weed free conditions to assess crop tolerance to these herbicides. Treatments that included Assert SC-300 @ 1000 g ai/ha caused injury rating of 10% 6 DAA. This injury was not significant 21 or 56 DAA. All treatments were safe on Prairie Carnation and all yields were similar to the weed free check.

In a separate experiment, Centurion was applied to Prairie Carnation at 24, 48 and 96 g ai/ha post-emergence in an area heavily infested with wild oats. Due to the high number of wild oats in this trial Centurion @ 96 g ai/ha was required to maintain 96% control. There was no visual injury to the crop with any rate of Centurion, from 24 to 96 g ai/ha and yields of all treatments were similar to the weed free check and better than the untreated check.

Weed Research Trials Conducted 2004 - 2008 (by crop)

Year	No Crop	Wheat	Barley	Oat	Prairie Carnation	Canary seed	Flax	Canola	Mustard	Sun flower	Bean	Chick pea	Lentil	Pea	Soy bean	Corn	Alfalfa	# of Trials	# of Treatments
2004		17	3	1		4	3	6	0	1	5	6	6	8	1	1	1	63	603
2005		4	1	2		3	2	4	2	2	2	4	3	3	2	2	3	39	900
2006		22	2	1		1	5	2	4	0	0	2	2	1	0	0	1	43	842
2007		19	1	1		0	5	6	1	0	0	3	3	3	0	0	0	42	723
2008	4	27	3	1	2		3	10				6	7	8				71	746
TOT		62	7	5		8	15	18	7	3	7	15	14	15	3	3	5	258	3814

- As part of our commitment to supporting the Minor Use Registration effort, our group (with funding provided by AFIF) successfully sought Good Laboratory Practices certification for field crop residue trials during the winter of 2004. Our program has been audited and re-certified by the Standards Council of Canada in 2006 and 2008. There were no major actions required as a result of the 2008 site visit and audit. Since 2004, we have successfully conducted the following trials under GLP practices:

Year	Crop	Location	Active Ingredient
2004	Desiray chickpea	Kernen CRF	sulfentrazone
2004	Chico chickpea	Kernen CRF	sulfentrazone
2004	Desiray chickpea	Goodale CRF	sulfentrazone
2004	Chico chickpea	Goodale CRF	sulfentrazone
2005	Annual caraway	Kernen CRF	azoxystrobin
2005	Oriental mustard	Kernen CRF	glyphosate
2005	Oriental mustard	Goodale CRF	glyphosate
2007	Industrial hemp	Kernen CRF	quizalofop-p-ethyl

A GLP trial (bromoxynil on industrial hemp) was planned for 2008 but was cancelled by AAFC at the last minute. The demand for the conduct of GLP trials at our facility has declined as a result of the major program initiated by AAFC at the Scott Research Farm. However, we continue to work closely with the AAFC program and are always seeking ways to collaborate and co-ordinate with it. It is our belief that the province could be best served by a complete integration of the programs at Scott and Saskatoon. The major benefits would be expanded capacity of the Scott program to conduct trials in two distinct environments (especially with respect to soil texture, soil OM content and soil pH) and to reduce the cost of maintaining GLP status for the Saskatoon site.

Management of Perennial Weeds in Direct Seeding Systems

One of the objectives of the program is to address weed control issues in direct seeding systems. To that end, we have paid particular attention to developing management systems for Canada thistle, Dandelion and foxtail barley. The work on Canada thistle and dandelion is a collaborative project with Dow AgroSciences and Mr. Bill May, AAFC, Indian Head. Funding for the Canada thistle portion is provided by Dow AgroSciences. Our dandelion project is funded through a separate ADF project grant while Bill May's work on this weed is funded by AAFC's MII program. Both projects involve the evaluation of six different herbicide regimes in a four year wheat – canola – barley – pea rotation with each phase of the rotation present each year for a total of 24 treatments. Our Canada thistle project is in its final year in 2008. Our dandelion project will be completed in 2009.

Management of Dandelion

Dandelion often becomes a significant problem in direct-seeding systems. It can be controlled but requires an on-going program to prevent re-invasion due to the ubiquitous nature of the species and its heavy production of wind dispersed seeds.

Several initial experiments were conducted and illustrate that:

- Combinations of glyphosate and either Express (tribenuron) or florasulam applied in the fall can provide effective control.
- Applications in September are more effective than those applied in late October.
- Spring burn-off applications can provide control similar to that of fall treatments but fall treatments result in higher crop yields.

An on-going study funded the Agriculture Development Fund confirms these results and demonstrates the value of including short-term residual products such as tribenuron or florasulam with glyphosate to delay the re-invasion of dandelion seedlings.

Management of Canada Thistle

A trial similar in nature to the dandelion project outlined above has been carried out over the past four years near Saskatoon with major funding from Dow AgroSciences. The six systems being evaluated include:

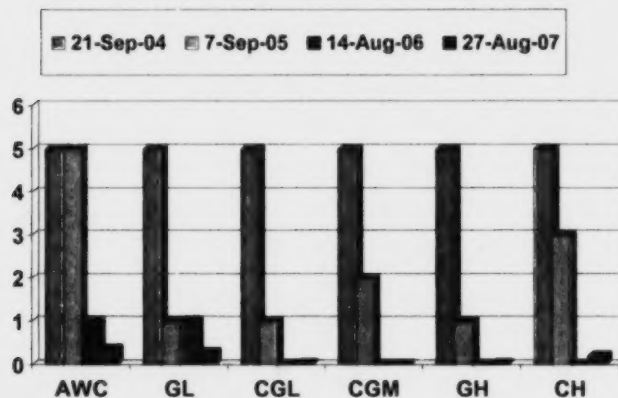
- Annual weed control only
- Glyphosate based system – low intensity
- Clopyralid + glyphosate system – low intensity
- Clopyralid + glyphosate system – medium intensity
- Glyphosate system – high intensity
- Clopyralid system – high intensity

All systems have been effective in maintaining low levels of Canada thistle infestation. A economic analysis of herbicide input cost vs crop returns (based on crop yield and grade to determine price) will be conducted.

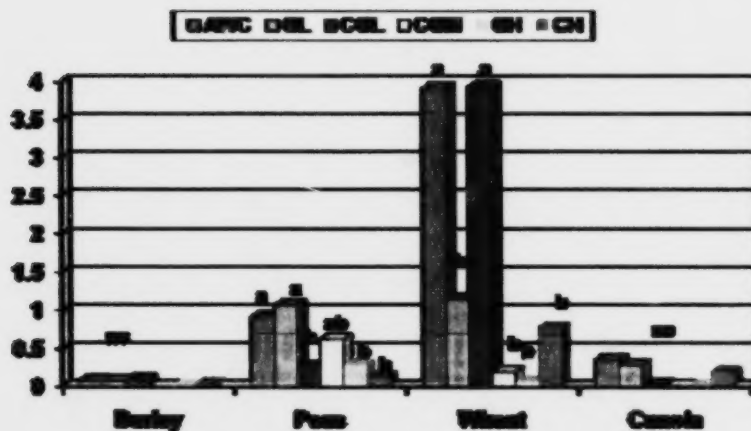
Initially the Canada thistle population was quite high but a heavy infestation of painted lady butterfly in the first growing season caused significant damage to the thistle throughout the trial. The four-year rotation of wheat – canola – barley – peas has been completed but detailed analysis of the 2008 field data has not.

The impacts of herbicide system and crop rotation up to the end of the third years of the project are illustrated in the two figures below:

Peas – Wheat – Canola 2007 Canada thistle Counts (#/M²)



2007 Canada thistle Counts (#/M²)



Canada thistle numbers have been quite low in barley & canola crops, somewhat higher in peas and often considerably higher in wheat which follows peas in the rotation. In terms of herbicide options for Canada thistle control, the pea crop is the weak link in the

rotation as Odyssey is the main option and it is not very effective for control of Canada thistle.

Management of Foxtail Barley

As with dandelion, foxtail barley quickly invades direct-seeding fields due to its abundance on roadsides, around sloughs and in saline areas and the fact that its seeds are wind dispersed. Our trials on this species have shown that:

- Glyphosate applied in early May controlled established plants but seedlings were not controlled as they emerged after the herbicide application.
- Delaying glyphosate application until late May provided superior control of established plants and also controlled seedlings.
- In spite of superior weed control with late May herbicide application, crop yield was higher when early May herbicide was combined with early seeding.
- When glyphosate was applied early, seeding to a dicot crop such as flax allowed for excellent in-crop control of foxtail barley seedlings with Assure II.
- Assure II did not improve control of established plants.
- Glyphosate applied in late May was superior to early May with respect to weed control but crop yield was greater with early treatment and crop seeding.

Evaluation of New Herbicides and Expanded Use Patterns for Existing Products

Work of this nature is a major component of the program. It is funded by herbicide manufacturers and distributors. The work consists mainly of evaluating new herbicides and adjuvants and new formulations of existing products. In some cases, and especially in the case of new formulations and adjuvants, the work is conducted under confidentiality agreements. Much of the work on new active ingredients and expanded use patterns for existing products has been reported in our annual progress reports. The major area of activity with respect to new products has been the evaluation of sulfentrazone and isoxaflutole as reported in the section on URMULE above. In 2008, we also conducted some work on pyrasulfotole (Infinity), pyroxsulam (Simplicity), carfentazone (Aim, CleanStart) and saflufenacil (Kixor). Data generated from these trials are supplied to the manufacturer's to support their requests for product registrations and use pattern expansions.

In terms of label expansions for existing products, we have conducted a very large amount of work with flucarbazone sodium (Everest) to refine the optimum rates and timing of application, to evaluate its use as a pre-emergent product for wild oat control, to assess its suitability for use on crops other than wheat and to define safe re-cropping

intervals for a wide range of rotational crops. These trials have been used by the manufacturer to refine its label directions for use and to enhance the utility of the product to farmers.

Two other examples of recent work on existing products are Fortress (triallate + trifluralin) and Avadex BW (triallate). There is renewed interest in these products as their rights have been acquired by a new company and the increasing problem of Group 1 resistant grass weeds is generating new interest in some of these older products.

We have been evaluating the efficacy of a mixture of group 4 products for control of hemp nettle and cleavers in wheat. Results have been quite promising but the manufacturer has asked us to keep the details of these trials confidential until regulatory approval has been granted.

Addressing the Group 2 Herbicide "Stacking" Question

The availability of a variety of soil residual Group 2 herbicides and the potential to use these in successive years led to the question of whether or not the use of two Group 2 herbicides in succeeding years could result in greater damage to a sensitive rotational crop than when either herbicide was used alone. That is, would the residues of the two herbicides in the soil behave in an additive or a synergistic manner. A project was carried out in collaboration with Dr. Jeff Schoenau of the Department of Soil Science and Eric Johnson of the AAFC Scott Research Farm and formed the basis of Mr. Bryce Geisel's MSc thesis. In summary, it was found that all of the reactions were additive rather than synergistic. The work has been published in Weed Science.

Soil Residual Herbicides and Re-cropping Intervals

During the reporting period a large number of trials have been devoted to assessing the risk of injury to sensitive rotational crops following application of a herbicide with soil residual properties. Our trials can be conducted on two distinct soil types, a clay loam at the Kernen Crop Research Farm and a sandy loam at the Goodale Crop Research Farm. This provides a good contrast in terms of carry-over risk as the clay loam soil with its higher organic matter content provides much lower risk of herbicide injury than does the sandy loam soil with lower organic matter.

During the reporting period, re-cropping trials have been conducted with the following herbicides:

Sulfentrazone re-cropped to wheat and barley 12 and 18 months after application on silt loam soil. (2004). Conclusions: Injury to wheat was only seen where sulfentrazone was applied 12 months prior to planting, at rates of 280, 420, 560, and 840 g ai/ha. There was no injury to wheat when sulfentrazone was applied 18 months prior to planting. Wheat yield was reduced significantly from the check only when sulfentrazone was applied at 840 g ai/ha (3x rate), 12 months prior to planting. Only the highest rate of sulfentrazone (840 g ai/ha) applied 12 months prior to planting reduced wheat stand.

Barley is more tolerant to sulfentrazone residues. Sulfentrazone at 560 g ai/ha, 12 months prior to planting caused initial injury but the barley recovered by the end of June. Season long injury was observed only when sulfentrazone was applied at 840 g ai/ha, 12 months prior to planting. Barley yield was greater than or equal to the untreated check with all treatments.

Sulfentrazone Re-cropped to Lentil 30 + 24 months after Application on Silt Loam Soil (2005). Conclusions: None of the herbicide treatments reduced plant stand and no visual injury symptoms were noted except the 840 g ai/ha applied in the spring of 2003 (24 months prior to seeding). Only 2 treatment reduced seed yield. 280 and 840 g ai/ha sulfentrazone applied pre-e 24 months prior to seeding reduced lentil yield but these rates applied 30 months prior to seeding lentil caused no damage, and 420 and 560 g ai/ha did not injure lentils seeded 30 or 24 months after application.

Sulfentrazone Recrop to Clearfield Lentil in a Silty Clay Loam 12 Months after Application (2008) Conclusions: Significant injury to lentil occurred where sulfentrazone rates of 280 and 560 g ai/ha were applied in 2007. The crop recovered slightly in the 280 g ai/ha treated plots as time went on but at 560 g ai/ha, crop injury increased with time. Crop stand was not affected by any sulfentrazone rate. This did not affect yield however there were other factors that could have affected lentil yield including very dry spring, poor lentil emergence, second flush of lentils, open fall with no frost until October.

Re-crop of Sulfentrazone to IMI Lentil in a Clay Soil 12 months after application. 2008. Conclusions: There was significant injury to lentil with treatments of sulfentrazone @ 210, 280 and 560 g ai/ha applied in 2007. Lentil yield appeared to be reduced when seeded into plots previously treated with sulfentrazone @ 280 and 560 g ai/ha. But only the highest sulfentrazone rate resulted in statistically significant yield reduction.

Sulfentrazone Re-cropped to RR Canola on Sandy Loam Soil 12 months After Application (2007). Conclusions: There was no injury to canola seeded 12 months after sulfentrazone application on sandy loam soil.

Sulfentrazone Re-cropped to RR Canola on Clay Loam Soil 12 months After Application (2007). Conclusions: There was no injury to canola seeded 12 months after sulfentrazone application in clay soil.

Isoxaflutole Recrop to Wheat and Canary Seed 12 Months After Application on Silt Loam Soil (2004). Conclusions: There was no visual injury to wheat or canaryseed from any of the treatments. Wheat and canaryseed yield, from all treatments, were similar to the untreated check.

Isoxaflutole Recrop to Wheat (12 months after application) on Silt Loam Soil (2005). Conclusions: Hrs wheat was safe to plant 12 months after the application of isoxaflutole.

Isoxaflutole Recrop to Lentil (24 months) on Silt Loam Soil (2005). Conclusions: No

visible injury symptoms were noted and lentil plant stand was not affected by the herbicide treatment. There was variability in lentil yield between treatments, however any yield reduction did not correlate with increased rates of isoxaflutole applied 24 months prior to seeding lentil.

Isoxaflutole Recrop to Lentil 24 Months After Application on Silt Loam Soil (2006).

Conclusions: There was no injury to lentil cropped 24 months after applications of isoxaflutole at rates up to 210 g ai/ha.

Recrop of Isoxaflutole to Mustard and Canola, Lentil and Pea (24 months) on Silt Loam Soil. (2004). **Conclusions:** There was no injury to canola seeded into soil treated with isoxaflutole 24 months prior to seeding. There was no visual injury to lentil or peas from any of the treatments. Plant counts of lentil and peas were not effected by any of the treatments. There was no significant difference in the yield of lentil and pea from any of the treatments. However, lentil yield was lower (not significant) on all isoxaflutole treatments compared to the weed free check. The yield of this trial was affected by an Aug. 20th frost.

Isoxaflutole and Sulfentrazone Recrop to Clearfield Lentil 12 Months After application on Clay Loam Soil (2007). **Conclusions:** Significant injury to lentil was observed on June 20th where sulfentrazone was applied at 140 g ai/ha and in treatments that had sulfentrazone at 280 g ai/ha in combination with any rate of Isoxaflutole. There was no significant yield difference with any of the treatments and plant stand was not affected. No data were collected for treatment #8 as there was a mixing error on that treatment.

Recrop of Isoxaflutole and Sulfentrazone to IMI Lentil in a clay soil (12Months) 2008. **Conclusions:** All of these plots had an application of sulfentrazone @ 280 g ai/ha in 2007. There was very little injury to lentils when averaged across all reps. However there were 4 plots where significant visual injury was evident on July 1st (413, 111, 214 and 117). None of the injury resulted in any crop stand or yield reduction.

Sulfentrazone Movement in Clay Loam Soil (2008) – collaboration with Dr. J. Schoenau (Soil Science) and Mr. Eric Johnson (AAFC, Scot Research Farm). Initial results from this work indicate that sulfentrazone will move downwards in soil to a limited extent with moisture percolating through the profile. However, it appears that this movement is minimal and there should be no threat to groundwater.

Emergency Plant Back And Crop Rotations Following Reduced Rates of Everest on Sandy Loam Soil (2004). **Conclusions:** No Crops were harvested from this trial due cool season causing late maturity and early frost causing significant crop damage. There was no significant difference in HRS Wheat plant count, height, days to heading or crop biomass from any of the treatments. The mean of the Aug 24 rating indicated >10% injury to wheat from Everest @ 30 and 60 g ai/ha. However some plots had >10% injury on the Aug 24th rating where Everest was applied at 10, 30, 40 and 60 g ai/ha. We are seeing a high degree of variability between plots with soil residual herbicides. There was no injury to the Clearfield Wheat from any of the treatments. There were high injury

ratings on the barley at each rating date and all treatments but injury was very variable between reps. There were usually 1 or 2 severely injured plots within each treatment. Based on these observations, barley should not be recommended for emergency plant back into Everest treated fields. There was noticeable injury to individual flax plots within each treatment. At the July 15 rating, the mean rating indicated significant injury from all treatments except Everest at 20 g ai/ha. By the Aug. 24 rating date the flax had out-grown most of the injury but it was still significant (>10%) from Everest @ 60 g ai/ha and the Ally treatments. Due to the variability between plots there is no significant difference between treatments for flax height, days to heading or plant biomass. With no yield data and the injury that was seen this year, flax should be tested further as an emergency plantback crop before it is recommended. There was no injury to Clearfield canola from any of the treatments. There was some residual control of prostrate pigweed and green foxtail with all treatments of Everest. Everest rates of 10 and 15 g ai/ha achieved suppression of green foxtail and rates of 20, 30, 40 and 60 g ai/ha controlled green foxtail 52 DAA. Everest at 30 g ai/ha reduced prostrate pigweed growth and rates of 40 g ai/ha was close to control. 60 g ai/ha of Everest and 4.45 g ai/ha of Ally controlled prostrate pigweed 52 DAA.

Emergency Plant Back And Crop Rotations Following Reduced Rates Of Everest – HRS Wheat, Clearfield Canola, Flax and Canaryseed on Sandy Loam Soil (2005).

HRS wheat, Clearfield canola and flax could be safely planted 4 days after application of Everest. Canaryseed yield was variable due to uneven distribution of green foxtail in the trial. Green foxtail was controlled in the other crops with in crop maintenance herbicides. There was some visual injury to canaryseed at the 30 and 60 g ai/ha rates of Everest, but it did not appear to affect yield. Redroot pigweed was controlled with Everest @ 60 g ai/ha and Ally @ 4.45 g ai/ha. Only green foxtail was suppressed with Everest @ 60 g ai/ha and Ally on the July 6 rating, but by the Aug 4 rating no treatment gave consistent suppression of green foxtail.

Everest Re-crop - Fall Seeded (2003) Crops on Silt Loam Soil (2004). Conclusions:

Winter Wheat and Fall Rye seeded 83 days after Everest application showed no injury prior to freeze-up in 2003. Winter wheat and fall rye can be safely seeded into Everest treated soil 80 days after application. Canada Western Extra Strong Wheat (CDC Rama) and Canada Prairie Spring Wheat (AC Vista) can be safely seeded into Everest treated soil 11 months after applications.

Everest 11 Month Re-crop - Spring Re-seeded Crops on Silt Loam Soil (2004).

Conclusions: **HRS Wheat** can be safely re-cropped 11 months after application. **Durum wheat** - There were no visual injury symptoms on Durum, and crop stand and days to heading were not affected. However, Everest @ 60 g ai/ha applied 11 months prior to seeding reduced crop yield significantly. **Barley** can be safely re-cropped 11 months after application. **Oat** - Treatment means indicate that there is no problem re-cropping oats 11 months after application, and no effects on the crop were noted at rates up to 30 g ai/ha. However, one plot where Everest was applied at 60 g ai/ha indicated significant growth reduction and chlorosis on the July 13 visual rating. This plot had the lowest yield of all plots. The low yield may be due to the delay in maturity and the early (Aug

20) frost. This may warrant further investigation. **Canaryseed**- Treatment means indicate that there is no problem re-cropping oats 11 months after application, and no effects on the crop were noted at rates up to 30 g ai/ha. However, one plot where Everest was applied at 60 g ai/ha indicated significant growth reduction and chlorosis on the July 13 visual rating. This plot had the lowest yield of all plots. The low yield may be due to the delay in maturity and the early (Aug 20) frost. This may warrant further investigation. **Canola**- Conventional and Clearfield canola can be safely re-cropped 11 months after an Everest application. **Sunflower**- Everest delayed the flowering of sunflower by 2-4 days. However, the yield of sunflower seeded 11 months after application was equal to or greater than the UTC. **Corn** - There was no seed yields harvested from the corn due to severe frost damage on Aug 20, corn was biomassed on Sept 14. Re-cropping corn 11 months after the application of Everest 30 g ai/ha appears to be safe. Some plots where Everest was applied at 60 g ai/ha had injury ratings that were higher than acceptable (>10%) on July 13 and Aug 5 rating dates. **Flax** - Flax can be safely re-cropped 11 months after an Everest application. **Field pea** - There was severe growth reduction and chlorosis to peas on two plots where Everest was applied @ 60 g ai/ha. However, the injury did not affect the yield of peas. There was no significant difference in pea yield from any of the treatments. Re-cropping peas into soil treated with 30 g ai/ha appears to be safe, but further testing of crop safety in overlap situations may be warranted. **Lentil** - Lentil seeded 11 months after Everest was applied at 60 g ai/ha showed severe growth reduction, chlorosis, delay in flowering, and yield reduction. 30 g ai/ha appeared to decrease yield, but yield was not significantly different from the UTC. The yield of lentils was affected by the Aug 20 frost. We do not recommend lentil as a re-crop option after Everest on soils of this type. **Pinto bean** - Pinto bean yield was severely affected by frost on Aug 20. Pinto Bean did not appear affected by Everest applied 11 months prior to planting, but further evaluations under normal growing conditions should be considered. **Soybean** - There was no yield of soybean due to a very cool growing season and frost on Aug 20. Soybean did not appear affected by Everest applied 11 months prior to planting, but further evaluations under normal growing conditions should be considered. **Chickpea** - Chickpeas that were planted into 60 g ai/ha, 11 months after application, showed severe chlorosis on June 30, and growth reduction on July 13. The Aug 5 rating shows they outgrew most of the injury. There was no harvestable yield of chickpea due to the cool growing season, Aug 20 frost, and early snow. We would recommend that chickpea be evaluated further before it is recommended as a re-crop option. **Alfalfa** - Alfalfa showed severe growth reduction when planted into Everest @ 60 g ai/ha, 11 months after application. However, there was no significant difference in dry weight biomass from any of the treatments. We recommend that alfalfa be looked at further before it is recommended as a re-crop option.

Crop Rotations Following Reduced Rates of Everest 12 months After Application on Clay Loam Soil (2005). **Conclusions:** **Oats** -When averaged across all reps there was no significant injury or yield reduction from any of the Everest rates. There was 1 plot @ 60 g ai/ha that showed injury symptoms throughout the year and had the lowest yield of all plots. **Barley**- There was no significant injury or yield reduction in barley. Plot 407 (30 g ai/ha) had significant visual injury in July and August ratings and the yield was lower than the other 30 g ai/ha plots. Plot 402 (60 g ai/ha) had low yield but no visual

injury. **Canola** – Canola was safe to recrop 12 months after Everest application.

Canaryseed- Canaryseed yield following treatments with 60 g ai/ha of Everest was significantly lower than following Everest at 10 and 15 g ai/ha but not significantly different from the untreated check. Two plots (#301 and #402) had very low yields. The lower yields did not completely correspond the plots that had the highest visual injury, plot 208 -30 g ai/ha and plot 301- 60 g ai/ha. **Yellow Mustard** – There were two strips of mustard seeded in this trial, one seeded May 12 and the other May 27. There was no significant injury or yield reduction when all reps were combined. There was one plot on each seeding date of the 60 g ai/ha rate that had severe injury and yield reduction, rep 3 on the first seed date and rep 4 on the second. **Juncea Mustard** - There was no significant injury or yield reduction when all reps were combined. Three plots, plot 405 (30 g ai/ha), plot 406 (20 g ai/ha) and plot 301 (60 g ai/ha) had lower yield than other reps for each treatment.

Lentil- Lentil yield on 60 g ai/ha Everest treatment was significantly reduced from the lentil yield on the 10 g ai/ha but similar to the untreated check and all other treatments. Note that the following plots had very poor seed set at the Aug 2 rating; plot 406 (20 gai), plots 208+303 (30gai), plot 304 (40 gai) and all 60 gai plots. There was severe yield reduction on plot 405 (15 gai), plot 208 (30 gai), plot 304 (40 gai) and plot 301 (60 gai). Lentil would not be recommended as a re-crop 12 months after Everest. **Chickpea**- Chickpea injury was not significant when all reps were combined. Yield was reduced at the 20 g ai/ha but the 30, 40 and 60 g ai/ha was not significantly different from the untreated check. Note- there was severe injury to plot 405(15 gai), plot 406 (20 gai) plot 301 (60 gai)and 108 + 207 (Ally). Chickpea would not be recommended as a re-crop 12 months after Everest. **Pinto Bean**- Pinto Bean was safe to re-crop 12 months after Everest application. **Soybean** -was safe to re-crop 12 months after Everest application. Low soybean yield due to frost. **Alfalfa**- Visual injury at 60 g ai/ha (reps 3 + 4) did not translate into less biomass. This may be due to the injury symptoms being less leaf development and thicker stems. **Sunflower** – Sunflower showed no signs of injury when re-cropped 12 months after Everest application. There was no yield taken due to Sclerotinia in June, Painted Lady Butterfly in July, and crows and frost in September. **Corn**- Corn was not significantly injured and there was no yield reduction when all reps were combined. However, there was severe injury and yield reduction to a number of plots; lot 405 (15gai), plot 406 (20 gai), plot 406 (20 g ai/ha, plot 303 (30 gai), plot 408 (40 g ai/ha) and plot 301 (60 gai). Corn would not be recommended as a re-crop 12 months after Everest application.

Everest Recrop - Spring Re-seeded Crops (24 months after application) on a Silt Loam Soil (2005). **Conclusions:** Oat yield was significantly reduced at the 60 g ai/ha rate of Everest. Plant height of oat at the 60 g ai/ha rate was also reduced, however it was not significantly different from the untreated check.. **Juncea mustard** and **Field Pea** were safe to recrop 24 months after Everest application. There was no significant injury or yield difference in **lentils** when all reps were combined, however there was severe injury and yield reduction in one plot (plot 203) at the 60 g ai/ha rate. **Chickpea** was safe to recrop 24 months after Everest application. **Pinto dry bean** and **soybean** were safe to recrop 24 months after Everest application. **Corn** cobs were severely frozen at the time

of harvest and the entire cob was weighed. There was no significant injury or yield reduction from any of the treatments, however, there was a lot of variability between reps at the 60g ai/ha rate. There was no significant injury to **alfalfa** or biomass reduction when reps were combined. However, one 60 g ai/ha plot that showed significant injury symptoms on the July 19th rating.

Everest Re-cropped To Spring Seeded Crops 12 Months After Application On Clay

Loam Soil (2006). Conclusions: **Oat:** One plot of Everest @ 20 g ai/ha had significant growth reduction on the Aug 10 rating date and an 8 cm. reduction in height from the UTC average, but there was no yield reduction. Everest @ 30 g ai/ha did not cause visual injury symptoms, height reduction or delay in maturity but oat yield was reduced. One plot of Everest at 40 g ai/ha had significant growth reduction on the July 17 and Aug 10 visual ratings. There was a 15 cm height reduction and a yield reduction on this plot. Three plots of Everest @ 60 g ai/ha had significant injury on the July 19 and Aug 10 rating, up to 22 cm. in height reduction, 7 day delay in maturity and a very significant yield reduction. It appears safe to plant oats on land treated with up to 20 g ai/ha of Everest in the preceding year. **Barley:** One barley plot in each set of Everest application notes showed indication of less growth. However there was no height reduction, maturity delay or yield reduction on these plots. It appears that barley can be safely planted the year following Everest application. **Chickpea:** There was no visual injury and all yields were similar to the Check. Desi chickpea can be safely planted the year following Everest application. **Peas:** There was significant visual chlorosis of pea vines on the July 7th rating on 3 of 4 plots where Everest had been applied @ 60 g ai/ha. The injury had disappeared by the July 19th rating and all yields were similar to the UTC. It appears peas can be safely planted the year following application of Everest. **Juncea mustard:** There was no significant injury to Juncea mustard and all yields were similar to the UTC. It appears that mustard can be safely planted one year following application of Everest. **Yellow mustard:** There was no significant injury to yellow mustard and all yields were similar to the UTC. Yields were variable but it appears that yellow mustard can be safely planted the year following Everest application. **Canaryseed:** There was no significant injury to canaryseed and all yields were similar to the UTC. Canaryseed can be safely planted one year following Everest application. **Alfalfa:** There was no significant injury to alfalfa and all yields were similar to the UTC. Alfalfa can be safely planted one year after application of Everest.

Crop Rotations in 2007 Following Pre-plant Everest in 2006 on a Clay Loam Soil.

Conclusions: **Lentil.** None of the treatments affected lentil plant stand, visual injury (assessed on June 4) or yield. Lentil injury >10% was noted on the June 28 rating where Everest was applied at 60 g ai/ha pre-plant, 20 g ai/ha pre + 10 g ai/ha at 2-6 leaf and 15 g ai/ha 2-6 leaf. Under these soil and weather conditions, lentil can be successfully grown in the year following Everest application up to a total of 60 g ai/ha. **Field pea.** There was no injury to peas from any of the treatments. Under these soil and weather conditions, field pea can be successfully grown in the year following Everest application of up to a total of 60 g ai/ha.

As can be seen, we have conducted a very large number of re-cropping trials, the

majority of them involving fulcarbazone-sodium (Everest). A summary of re-cropping results with Everest is contained in the following table:



Re-cropping 11 months after Everest Summary

	15 gal/ha			20 gal/ha		30 gal/ha			40 gal/ha		60 gal/ha		
Crop / Year	2004	2005	2006	2005	2006	2004	2005	2006	2005	2006	2004	2005	2006
Wheat	0					0					0		
Durum	0					0					0		
Flax	0					0					0		
canola	0	0		0		0	0		0		0	0	
Soybean	0	0		0		0	0		0		25%	0	
Pinto bean	0	0		0		0	0		0		25%	0	
Sunflower	0	0		0		0	0		0		0	0	
Canaryseed	0	0	0	0	0	0	0	0	0	0	25%	25%	
Field pea	0	0	0	0	0	0	0	0	0	0	50%	25%	
Alfalfa	0	0	0	0	0	0	0	0	0	0			0
Barley	0	0	0	0	0	0			0	0	0	0	0
Oat	0	0	0	0		0	0	0	0	25%	25%	25%	
Yellow mustard		0	0		0		0	0	0	0		25%	0
Juncea mustard		25%	0	25%	0		0	0	0	0		25%	0
Chickpea	0	25%	0	25%	0	0	0	0	25%	0		25%	0
Lentil	0	0	25%	25%		0	50%	25%	25%				
Can	0	25%		50%		25%	50%		25%			25%	

Number on Chart represents the percent of plots that had injury on a 4 rep trial
 = visual injury but no yield reduction

Effects of Herbicide Stress on N Fixation in Field Pea and Chickpea.

A project was carried out in collaboration with Dr. Fran Walley, Department of Soil Science, to determine if the crop stress resulting from herbicide application to the crop or from planting the crop in soil containing herbicide residues known to affect the crop might affect the symbiotic relationship between the crop and the Rhizobia bacteria and thus reduce the amount of N fixed by the plant. This work formed the basis of Ms. Angela Taylor's MSc thesis. In summary, while there was some initial suppression of N fixation, there was no long-term affect and the total amount of N fixed by the crop was not affected.

Herbicide Resistant Weed Issues

A number of trials have been conducted to deal with existing herbicide resistance issues and to prepare for possible future developments.

As nearly all kochia in Saskatchewan is now resistant to group 2 herbicides, a number of trials have been conducted to evaluate the control of Group 2 resistant kochia in wheat. (Note that our first field experiment to confirm Group 2 resistance in this weed was conducted at Loreburn, SK in 1987). Fortunately, there is a wide variety of Group 4 herbicides that are effective against this weed. However, we have found that the rate of 2, 4-D usually tank-mixed with Group 2 products is not sufficient to provide adequate control. Additionally, a new and, as yet unregistered, herbicide containing 3 different

majority of them involving fulcarbazone-sodium (Everest). A summary of re-cropping results with Everest is contained in the following table:



Re-cropping 11 months after Everest Summary

Crop / Year	15 g/ha			20 g/ha		30 g/ha			40 g/ha		60 g/ha		
	2004	2005	2006	2005	2006	2004	2005	2006	2005	2006	2004	2005	2006
Wheat													
Durum													
Flax													
canola													
Soybean											25%		
Pinto Bean											20%		
Sunflower													
Canaryseed											25%	25%	20%
Field pea											50%	25%	70%
Alfalfa											70%	70%	
Barley									20%	20%			
Oat					25%					25%	25%	25%	70%
Yellow mustard				20%								25%	
Juncea mustard		25%		25%								25%	
Chickpea		25%		25%					25%		100%	25%	
Lentil				25%			50%		25%		100%	100%	50%
Corn		25%		50%			25%		25%		70%	25%	

Number on Chart represents the percent of plots that had injury on a 4 rep trial

□ = visual injury but no yield reduction

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Group 4 herbicides is providing excellent control at the expected label rate. In addition to these trials, we are also collaborating with Dr. Hugh Beckie and Eric Johnson of AAFC who is conducting biology and management studies in Group 2 resistant kochia.

Control of Group 2 Susceptible And Resistant Kochia In Wheat With Alternative Herbicides (2007). Conclusions: Group 2 resistant kochia was suppressed 75% by Buctril M, Controlled at 83% with Refine Extra + Banvel @ 15 + 53 g ai/ha. Kochia was controlled >93% with Attain @ 80+ 420, Attain @ 108+560, Dyvel @ 525, Optica Trio @ 1600, Prestige @ 144+660, Target @ 600, Trophy + MCPA @ 108+450, Infinity @ 205 and Florasulam + Fluroxypur @ 2.5 + 100 g ai/ha. In an adjacent trial, Group 2 resistant kochia was suppressed with 2,4-D at 560 g ai/ha and Banvel at 70 g ai/ha. Kochia was controlled with 2, 4-D at 840 g ai/ha and Banvel at 107 and 142 g ai/ha.

Control of Group 2 susceptible and resistant kochia in wheat with alternative herbicides (2008). Conclusions: Kochia was not controlled with Refine Extra as this population is group 2 resistant. The group 2 + 4 product, Frontline 2, 4-D, controlled the small kochia 88%, 13 DAA but overall provided 43% at 27 DAA. Group 2 + 4 products Triton K and GF 184 controlled kochia >97%. Kochia was not controlled with 2, 4-D @ 420 or 560 g ai/ha or with Buctril M @ 560 g ai/ha. All of the other Group 4 products controlled kochia >97%. Infinity @ 205 g ai/ha controlled kochia 87% and florasulam + Pardner @ 5 + 280 g ai/ha controlled kochia 85%.

Group 1 Resistant Wild Oat Control. For a number of years we have had a population of Group 1 resistant wild oats at the Kernen Crop Research Farm and have conducted a number of trials to evaluate control of this population in wheat and in field pea. The results confirm that a single resistant population can respond differently to herbicides in the group in question.

Wheat - 2007. Pyroxsulam, Everest and Axial controlled all wild oats in this population. The other products ranked as follows from best to worst: Horizon, Puma 120 Super, Achieve liquid, Assert and last Hoegrass 284.

Wheat - 2008. Wild oats were controlled >95% with Assert @ 364 g ai/ha, Simplicity @ 30 g ai/ha, Everest @ 60 g ai/ha and Axial @ 120 g ai/ha. Axial was the only group 1 product to control the group 1 resistant wild oats in this population.

Pea - 2007. Odyssey controlled all wild oats 100%. Near perfect control was observed with Select and Pursuit Ultra. The rest of the herbicide ranked as follows best to worst: Venture > Poast Ultra = Assure II > Pursuit. This group 1 resistant population is susceptible to group 2 graminicides (Odyssey) and also to the group 1 product, Select.

Pea - 2008. Wild oat control was greater than 93% with Select @ 96 g ai/ha, Pursuit @ 100 g ai/ha, Odyssey @ 60 g ai/ha and Poast ultra + Pursuit @ 422 + 50 g ai/ha. Select was the only group 1 herbicide to control the group 1 resistant wild oats in this population. Poast Ultra + Pursuit controlled the wild oats better than either product alone.

Emerging Weed Problems

Japanese brome: This annual grass weed is sometimes confused with downy brome but it behaves much more like a spring annual whereas downy brome is primarily a winter annual species. Spring seedlings of Japanese brome may also be confused with wild oat seedlings and so the weed often goes undetected until significant numbers have built up in a field. Trials were conducted in 2007 and 2008 to assess the level of control provided by graminicides commonly used in wheat and field peas. **Conclusions:** **Wheat 2007.** Pyroxsulam (Simplicity) and flucarbazone-sodium (Everest) (both Group 2 products) and Axial (a relatively new Group 1 product) controlled all wild oats in this population. The other Group 1 products ranked as follows from best to worst: clodinafop (Horizon), fenoxaprop (Puma 120 Super), tralkoxydim (Achieve Liquid), imazethabenz (Assert – group 2) and last diclofop-methyl (Hoegrass 284). **Pea 2007.** Near perfect control was observed with clethodim (Select, Centurion) (Group 1) and (sethoxydim (Group 1) + imazethapyr (Group 2) (Pursuit Ultra). The rest of the herbicide ranked as follows best to worst: fluazifop (Venture) > Poast Ultra = quizalofop (Assure II) > Pursuit. This group 1 resistant population is susceptible to group 2 graminicides (Odyssey) and also to the group 1 product, Select.

2008. Conclusions: Japanese brome population was low in this trial. All treatments suppressed or controlled Japanese brome. Solo (20 g ai/ha) provided the best level of control (100%). Assure II (48 g ai/ha) and Pursuit (50 g ai/ha) were next best at 93% control. Poast Ultra at 210 g ai/ha, Odyssey at 30 g ai/ha and Poast Ultra + Pursuit at 211 + 25 g ai/ha all provided 85% control, Select at 48 g ai/ha provided 70% control. Equinox at 40 g ai/ha provided 78% control. Select at 48 g ai/ha provided the lowest level of control at 70%.

Winter annual cleavers: Prior to wide-spread adoption of direct seeding systems, cleavers was primarily a spring annual weed. More recently, the winter annual form has become more common and can be difficult to control in early spring. Trials to evaluate herbicides for control of over-wintered cleavers plant were conducted in 2007 on both clay loam and silty loam soils. **Conclusions:** Quick burndown of winter annual cleavers was observed with Roundup + Aim @ 450 + 8.9 g ai/ha, Roundup + Attain @ 450 + 108 + 564 g ai/ha and Roundup + Optica trio @ 450 + 900 g ai/ha. At 19 days after application all treatments controlled the cleavers however cleavers treated with Roundup + Aim @ 450 + 8.9 g ai/ha showed signs of re-growth. A poster summarizing this work was presented at the Soils & Crops Workshop in Saskatoon in March of 2008.

Timing of treatments for winter annual weeds: The objective of this trial is to determine if the best strategy is to control winter annual weeds early in the growing season (early May), even if seeding is to be delayed till later in the spring (late May) as opposed to controlling them just prior to a late seeding date. **Conclusions:** All the winter annual weeds, flaxweed, narrow-leaved hawk's beard, Canada fleabane and shepherd's purse, were controlled equally by PrePass, Express + glyphosate, glyphosate @ 450 g ai/ha and glyphosate @ 900 g ai/ha at both application dates by the June 13 rating date. When analyzed factorially, soil moisture content on June 6 was greater with

early application/late seeding, followed by early application/early seeding. Late application/late seeding resulted in the lowest soil moisture levels. There was significantly higher yield with early application/late seeding compared to both early application early seeding and late application/late seeding. There was no benefit from increasing the glyphosate rate from 450 g ai/ha to 900 g ai/ha.

Canada fleabane: Since 2000, a number of populations of Canada fleabane in the eastern USA have evolved resistance to glyphosate (Roundup) and resistant populations have now been confirmed in at least 15 states.. This native species occurs in Saskatchewan but has not become a significant weed problem, at least not yet. However, because of its seeming propensity to develop resistance to glyphosate and because it produces a large number of wind-dispersed seeds, we have been evaluating a number of herbicides for its control. We believe that this weed deserves special attention because the evolution of glyphosate in a weed that could become a serious problem would seriously jeopardize the sustainability of our direct seeding system of crop production since the system depends entirely on the effectiveness of glyphosate.

In 2007 we, in collaboration with Eric Johnson at the AAFC, Scott Research Farmand Monsanto Canada, Inc., began a screening trial to evaluate glyphosate and other herbicides for control of this weed. Conclusions: Roundup Weathermax controlled Canada fleabane at 100%. Over 90% control was achieved with Liberty and Amitrol 240. Over 80 % control was achieved with Lontrel at all rates, 75,100 and 150 g ai/ha, 2,4-D LV600 @ 700 g ai/ha and Banvel II @ 140 g ai/ha. Over 70 % control was seen with 2,4-D LV 600 @ 560 g ai/ha and florasulam @ 5 g ai/ha. All other treatments gave less than 70% control of Canada fleabane. Narrow-leaved Hawk's beard was controlled 90, 98 and 100% with Liberty, Amitrol 240 and Roundup Weathermax, respectively. Florasulam gave 74% control of Narrow-leaved hawk's beard. Flixweed was controlled,>80%, with 2, 4-D LV 600 @ 560 and 700 g ai/ha, Amitrol 240, Roundup Weathermax and Optica Trio. Florasulam gave 76% control of Flixweed. Amitrol 240 and Roundup Weathermax provided 95% and 97% control of dandelion, respectively. Liberty resulted in 87% control of dandelion. All other treatments were ineffective on this weed. NOTE: conclusions are based on visual ratings31 DAT on weeds growing in a non-crop situation. Control with florasulam may improve if it has a surfactant added with it at application.

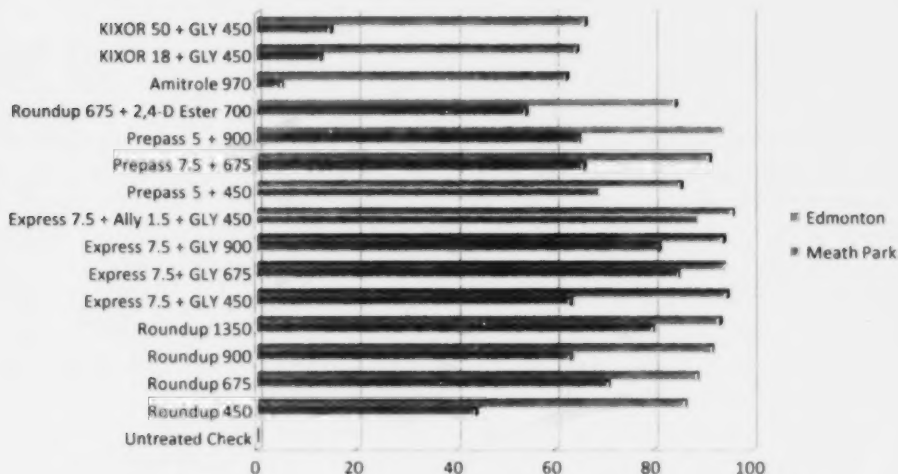
In 2008 a similar trial was conducted at the Goodale Research farm and the following observations were made: At 7 DAA Kixor @ 18 g ai/ha controlled Canada Fleabane 94%, however some of these plants regrew and control was reduced to 87% and 78%, 22 DAA and 46 DAA respectively. At 22 DAA > 90% control of Canada fleabane was achieved with Liberty @ 500 g ai/ha, Amitrol 240 @ 1000 g ai/ha, Roundup Weathermax @ 675 g ai/ha and Florasulam @ 5 g ai/ha + Merge @ 0.5 % v/v. At 46 DAA > 95% control of Canada fleabane was achieved with Banvel @ 140 g/aiha, 2,4-D LV 600 @ 700 g ai/ha, Lontrel @ 75,100 and 150 g ai/ha, Liberty @ 500 g ai/ha, Amitrol 240 @ 1000 g ai/ha and Roundup Weathermax @ 675 g ai/ha. Narrow-leaved hawk's beard was controlled > 80% with Liberty @ 500 g ai/ha, Amitrol 240 @ 1000 g ai/ha, Roundup Weathermax @ 675 g ai/ha, florasulam @ 5 g ai/ha and Kixor @ 18 g ai/ha.

The Canada fleabane at this site is not resistant to glyphosate and these data show there are a number of alternative herbicides that will control this weed when applied in the spring.

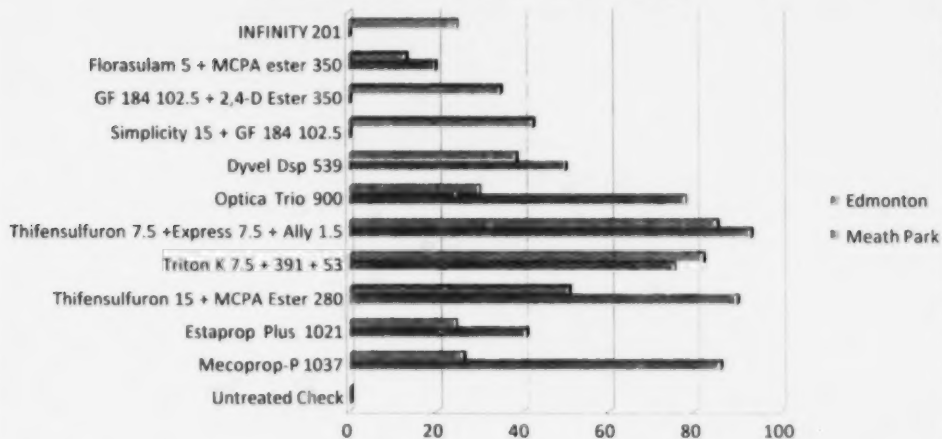
A poster summarizing the results of this work was presented at the 2008 annual meeting of the Canadian Weed Science Society.

White cockle. Over the past number of years we have been hearing increasing concerns about this perennial weed. It can be a problem in forage crops (particularly alfalfa) and also occurs in crop land recently taken out of forages. It appears to prefer light textured soils in the black soil zone. In 2008 we initiated a project in collaboration with Dr. Steve Shirtliffe to investigate the biology & ecology of the weed (Shirtliffe) and its control with herbicides (Holm & Sapsford). Shirtliffe's portion of the project is supported by an ADF grant. The herbicide work is funded by several herbicide manufacturers / distributors. Two herbicide sites were established, one at Meath Park, SK and one at Bruderheim, AB which is NE of Ft. Saskatchewan. The Alberta site is managed by Dr. Linda Hall of the University of Alberta. Pre-seed burn-off, in-crop, pre-harvest and post-harvest treatments are being evaluated. Preliminary results from 2008 indicate that pre-seed burn-off treatments that include glyphosate alone at 675 – 1350 g ai/ha or glyphosate at 450 – 900 g ai/ha mixed with a group 2 herbicide or herbicides will provide significant control of this species. Pre-emergence (to the crop) applications of low rates of glyphosate with Kixor were not as effective. Adding 2, 4-D to 675 g ai/ha of glyphosate did not improve control. Amitrole at 970 g ai/ha was not effective. Response to in-crop treatments varied considerably between the two sites. Group 2 products resulted in the best control at both sites. Mecoprop was effective at Meath Park but not at Bruderheim. Infinity, Frontline, Gf 184 + 2, 4-D LVE, Simplicity + GF 184 were not effective at either site but the latter 2 treatments showed considerably more activity at Bruderheim. Dyvel was equally poor at both locations as was Estaprop. An experimental mixture of group 4 products was much more effective at Meath Park than at Bruderheim. The treatment lists will be modified in response to results obtained in 2008 and the trials will be continued in 2009.

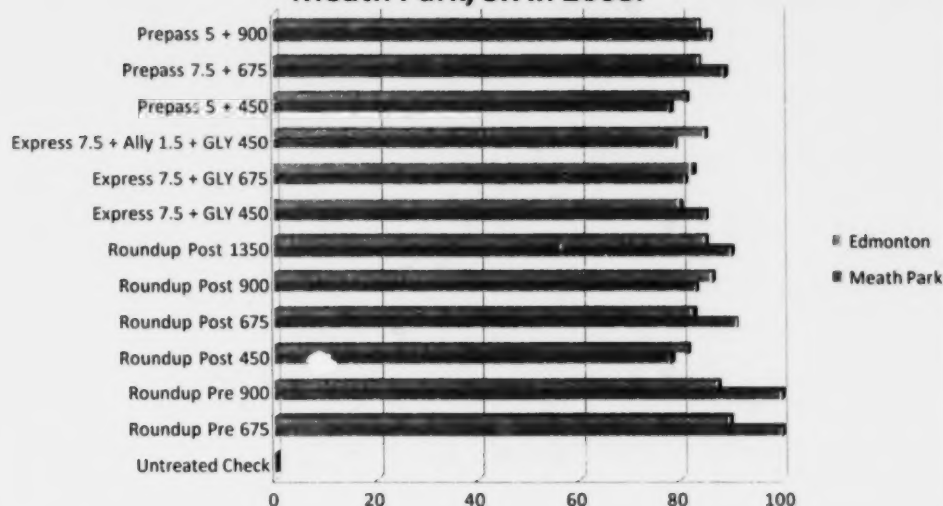
**Control of White Cockle (%) 89 DAA with Pre-emergence
Herbicides at Bruderheim, AB and Meath Park, SK in 2008.**



**Control of White Cockle (%) 56-84 DAA With In-crop Treatments at
Bruderheim, AB and Meath Park, SK in 2008.**



Control of White Cockle (%) with Pre-harvest and Post-harvest Treatments at Bruderheim, AB and Meath Park, SK in 2008.



Support of / Collaboration with CDC Scientists

Our program collaborates with and supports other CDC scientists on a number of fronts. We annually conduct a screening trial with Dr. Brian Rossnagel to determine the herbicide tolerance of new oat and barley varieties and advanced breeding lines. Commonly used herbicides are applied to these crops at 2X the recommended rate to determine if any of the new lines that may be released as varieties have any greater sensitivity to herbicides than the existing varieties. Observations over the years have not identified any lines with differential response to any of the commonly used herbicides that would warrant special precautions.

We are also collaborating with Dr. Pierre Hucl in an effort to improve the rooting ability (and thus the drought tolerance) of wheat lines by exposing them to a root pruning herbicide in the field and identifying those lines that appear to suffer the least damage. The theory is that these lines will have stronger root systems. Whether this translates into greater drought tolerance remains to be determined.

In 2008 we collaborated with Dr. Curt McCartney, recently appointed cereal & flax pathologist in the Crop Development Centre, to evaluate a new candidate fungicide for leaf diseases in wheat. Results have been forwarded to the manufacturer to support the

application for registration.

Finally, we are collaborating with Drs. Bunyanin Tar'an and Sabine Banniza in the Crop Development Centre in a project to determine if the stress caused by herbicide treatment of chickpeas results in increased crop susceptibility to disease. These studies were initiated in 2008 and will continue for two more years. We have, on several occasions and again in 2008, assisted Dr. Banniza's program by using our equipment to apply fungicide treatments to pulse crops.

Expanding Weed Control Options for Lentil

The introduction of Clearfield lentil 3 years ago has proven to be very popular with producers and demand for seed of CL lentils is high. The imidazolinones herbicides registered on these varieties is providing much superior weed control compared to the previous commercial standard (Sencor) and the absence of herbicide injury is resulting in more vigorous crops. The one weakness in the CL lentil program is the abundance of Group 2 resistant kochia in the main lentil producing areas. To address this situation we have, in collaboration with Dr. Bert Vandenberg, initiated (with SPG funding) a project that seeks to improve the tolerance of lentil to sulfentrazone, a herbicide that is particularly effective on kochia and which was recently registered for use on chickpea.

Preliminary indications are that there is variation in the susceptibility of some existing varieties and within a segregating population. Future efforts will be aimed at confirming this and determining if there is an exploitable level of tolerance in any of the material under test.

A poster based on this field work was presented at the Canadian Pulse Research Conference in Winnipeg in November of 2008.

Over the winter, an undergraduate student has been screening all of the currently registered lentil varieties and some advanced breeding lines for sulfentrazone tolerance. None of the varieties exhibited true resistance but there is considerable variation among varieties in their tolerance to the herbicide and this encourages us that it may be possible to select varieties that are sufficiently tolerant to allow for registration of the herbicide on the crop.

Competitiveness of new canola cultivars. We are collaborating with Dr. Neil Harker, AAFC, Lacombe, AB, to determine the competitiveness of new canola cultivars & hybrids relative to some older varieties and to other crop types such as barley, wheat, rye and triticale. Information generated in the 1970s suggested that canola was less competitive than barley and was as or slightly less competitive than wheat. For the past several years, there has been the generally held belief that canola cultivars and especially the hybrids are more competitive than older varieties. At the same time, the introduction of semi-dwarf barley and wheat varieties has resulted in a reduction in competitive ability of these varieties. Thus, the time is appropriate to re-examine the relative competitiveness of major field crops in light of increasing emphasis on Integrated weed Management Systems and the interest in reducing herbicide use and application rates.

We have conducted a 14 treatment (variety) trial in both 2007 and 2008. The data have been submitted to Dr. Harker and will be combined with data from other sites across the prairies for analysis and preparation of a report.

(f) Acknowledgements

The work reported here could not have been done without the help of many individuals and the financial support of many organizations. We would especially like to acknowledge the excellent technical support provided by our Research Technicians, Mr. Gerry Stuber, Ms. Teri Ife and Ms. Arlene Sagin as are the approximately 20 summer students who have worked in our program over the past five years. They are absolutely key to the success of the program. Also, Mr. Kirk Blomquist, Field Superintendent in the Dept. of Plant Sciences, and his staff who maintain the research land that we use provide invaluable service. Holm also wishes to acknowledge the tremendous support provided by the co-author of this report, Mr. Ken Sapsford, who received the Distinguished Agrologist award from The Saskatchewan Institute of Agrologists in April, 2008.

Financial support provided by the following organizations is very much appreciated.

- Adjuvants Plus
- Agricores United (now Viterro)
- Agriculture Development Fund, Sask Ministry of Agriculture
- Agri-Food Innovation Fund, Sask Ministry of Agriculture
- AAFC Minor Use Registration Program
- Arysta Life Science Canada Inc.
- Bayer CropScience Canada Inc.
- BASF Canada Inc.
- Canadian Food Inspection Agency.
- Crop Development Centre, University of Saskatchewan
- Dow AgroSciences Canada Inc.
- E.I. du Pont Canada Company.
- FMC Corporation.
- Gowan Canada
- Isagro
- Monsanto Canada Inc.
- Norac Concepts Inc.
- Nufarm Agriculture Inc.
- Provincial Council of ADD Boards.
- Saskatchewan Crop Insurance.
- Saskatchewan Pulse Growers.
- Syngenta Crop Protection Canada Inc.
- United Agri Products Canada.
- Western Agricultural Research Corporation.

(g) Literature Cited

Nil

(h) Appendices

Hard copies of the following are being submitted with the hard copy of this report:

Posters presented at Research and Extension Conferences / Workshops.
Abstracts of papers published in refereed scientific journals.
Annual Research reports prepared by our research group.
Samples of media mentions of research conducted.

(i) Other (Technology Transfer)

2004 -05:

Technology Transfer Activities _ K. L. Sapsford:

June 2, 2004 – Seeding Trends – Seager Wheeler Farm
Presentation – Soil residual herbicides
200 producers present

Aug 31, 2004 – Industry Agronomist Tour – Crop Development Centre
Toured trial on re-cropping of Everest
40-industry agronomists

Nov 29 – Dec 1, 2004 – Canadian Weed Science Society annual meeting
Poster – Fall Control of Dandelions

Dec 3, 2004 – Saskatchewan Soil Conservation Association – Agronomist
update Presentation – Dealing with Dandelions
80-industry agronomists

Jan 10, 2005 – Sask Pulse Growers annual meeting
Poster – Potential Broadleaf Herbicide for Chickpea

Jan. 2005 Arvesta Meeting
o Everest – Emergency Plantback 2004
o Everest Re-crop 2004

Jan 27, 2005 – Crop Life Canada, Sask Meeting
Presentation – Volunteer Control of Herbicide Tolerant Crops
45-industry agronomists

Feb 15-16, 2005 – Saskatchewan Soil Conservation Association Direct
Seeding Conference, Saskatoon, SK

Poster – Fall control of Dandelions
600 producers

Feb 17-18, 2005 – Soils & Crops Workshop, Saskatoon, SK
Poster – Fall control of Dandelions
Presentation – Group 2 herbicide Stacking results
80 agronomists

Mar 8-10, 2005 – Western Society of Weed Science annual conference
Poster – Fall control of Dandelions

Mar 16, 2005 – Sask Ag and Food Rural Revitalization Update
Presentation – Dandelion and Canaryseed Research

Mar 16, 2005 – Agronomy Seminar at Borden
Presentation – Dealing with Dandelions

Mar 31, 2005 – Enviro Test Lab Agronomy Meeting
Presentation – Group 2 Herbicide Stacking

Technology Transfer Activities of F.A. Holm

Papers Published in Refereed Journals:

Field Performance of Imazamox-Resistant Spring Wheat. C.J. Pozniak, F.A. Holm and P.J. Hucl. 2004. Can. J. Pl. Sci. 84:11205-1211.

Contributed Papers - Published Conference Proceedings & Abstracts

K. Neil Harker, G.W. Clayton, R.E. Blackshaw, J.T. O'Donovan, E.N. Johnson, Y. Gan, R.P Zentner, R.B. Irvine, **F.A. Holm** and R.C. Van Acker. **Persistence of glyphosate resistant wheat and canola volunteers in Western Canada.**

- Proceedings, Weed Science Society of America, Honolulu, HI. February, 2005. (Poster and Abstract).

K. Sapsford, **F.A. Holm** and E. Johnson. **Fall control of dandelion (*Taraxacum officinale*) don't wait too long.** Soils and Crops Workshop, University of Saskatchewan, Saskatoon, SK. February, 2005. (Poster and Abstract).

- Proceedings, Canadian Weed Science Society annual meeting, Winnipeg MB. November, 2004. (Poster and Abstract)
- Proceedings, Saskatchewan Soil Conservation Association annual conference, Saskatoon, SK. February, 2005. (Poster and Abstract)
- Proceedings, Soils and Crops Workshop, University of Saskatchewan, February, 2005. (Poster and Abstract)

E.N. Johnson, D.A. Ulrich, R.E. Blackshaw, W.E. May, **F.A. Holm** and K.L. Sapsford. **Isoxaflutole and sulfentrazone – potential herbicides for chickpea.** Proceedings, Pulse Days 2005. Saskatchewan Pulse Growers p 55. (Poster and Abstract).

B. Vandenberg, J. Bertholett, M. Kuchuran, **R. Holm** and S. Chant. 2004. **Imidazolinone Tolerant Lentil in Canada.** Proceedings, Pulse Canada Research Workshop, London, ON. November 29-30, 2004. (Poster and Abstract)

R.P. Zentner, **F.A. Holm**, A.G. Thomas, and K. Sapsford. 2005. Effects of **Integrated Crop Management Practices on the Agronomic and Economic Performance of Cropping Systems in the Dark Brown Soil Zone of Saskatchewan.** Saskatchewan Soil Conservation Association annual conference, Saskatoon, SK. February, 2005. (Poster and Abstract)

Dept. Visits & Tours (approx. attendance)

July 23, 2004. National Minor Use Registration of Pesticides tour of weed control research plots (22).

July 22, 2004. Canadian International Grains Institute – Canadian Special Crops Association delegation from Brazil (6)

July 29, 2004. Agricore United agronomy specialists tour of weed research plots. (11)

2005 - 06:

Newspaper and magazine articles

- May 18 – Western Producer – Round-leaved mallow
- Fall 2005 – Top Crop Manager – Round-leaved mallow
- Fall 2005 – Top Crop Manager – Group 2 Herbicide Stacking
- Winter 2005 – Top Crop manager – Dandelion management
- Summer 2005 – Top Crop Manager – Broadleaf weed control in chickpea
- Feb 2006 – Grainews – Round-leaved mallow control
- Sep. 2005 – Farm & Food Report – Fall dandelion control

Posters presented

- Nov 2005 – Canadian Weed Science Society - Sequential Herbicide Effect on Field Pea
- Jan 2006 – Pulse Days in Saskatoon – Sequential Herbicide Effect on Field Pea
- Mar 2006 – Soils & Crops Workshop, Saskatoon– Sequential Herbicide Effect on Field Pea
- Feb 2006 – SSCA Direct Seeding Meeting, Regina – Sequential Herbicide Effect on Field Pea
- Mar 2006 – Soils & Crops Workshop, Saskatoon – Crop Rotation 11 Months After Everest Application

- Mar 2006 - Sulfentrazone/isoxaflutole combinations for weed Control in Chickpea – Western Society of Weed Science

Presentations & Field Tours

- July 21, 2005 – Sask Pulse Tour
- July 22, 2005 – Hosted the Provincial Weed Tour
- Swift Current Field Day July 28, 2005
- Nov 2005 – CWSS Working Group – Reduced rate of Isoxaflutole and Sulfentrazone on Chickpea
- Jan 2006 – Arysta COI meeting – 8 presentations on the results of Everest in different trials
- Jan 2006 Plant Sciences Booth, Crop Production Show

2006-07:

Refereed Journal Articles:

Agronomic and economic responses to integrated weed management systems and fungicide in a wheat-canola-barley-pea rotation. F.A. Holm, R.P. Zentner, A.G. Thomas, K. Sapsford, B.D. Gossen, O. Olfert and J.Y. Leeson. *Can. J. Pl. Sci.* **86**: 1281–1295. 2006.

Nutrient Availability and Yield of Wheat Following Field Pea and Lentil in Saskatchewan, Canada. Dylon R. Adderley, Jeff J. Schoenau, Rick A. Holm, and Peiyuan Qian. *Journal of Plant Nutrition*, 29: 25–34, 2006.

Effect of dew temperature, post-inoculation condition, and pathogen dose on suppression of scentless chamomile by *Colletotrichum truncatum*. G. L. Graham, G. Peng, K. L. Bailey, & F. A. Holm. *Biocontrol Science and Technology*, 2006; 16(3): 271–280.

John T. O'Donovan, K. Neil Harker, George W. Clayton, Linda M. Hall, Jason Cathcart, Kenneth Sapsford, F. A. (Rick) Holm and Kristin Hacault. 2007. **Volunteer barley interference in spring wheat grown under zero tillage.** *Weed Science*. Accepted Oct 06

G. L. Graham, G. Peng, K. L. Bailey, and F. A. Holm. 2006. **Interactions of *Colletotrichum truncatum* with Herbicides for Control of Scentless Chamomile (*Matricaria perforata*).** *Weed Technology*. 2006. Volume 20:877–884

Research Posters presented:

Effect of wheat seeding rate on volunteer barley interference in imidazolinone-tolerant wheat. 2006. J.T. O'Donovan, K.N. Harker, G.W. Clayton, L.M. Hall, J. Cathcart, K. Sapsford and F.A. Holm. *Weed Sci. Soc. of America annual conference*, New York, NY. February, 2006. (Poster).

In Search of New Herbicide Chemistries for the Prairies. Eric Johnson, Dan Ulrich, **F.A. Holm**, **Ken Sapsford**, Robert Blackshaw, and William May. Proceedings, Soils & Crops, 2006. University of Saskatchewan, Saskatoon, SK., March 2-3, 2006.

Field Pea Response to Sequential Herbicides. **K. Sapsford**, **F.A. Holm** and E. Johnson. 2006. Proceedings PulseDays January, 2006. Saskatoon, SK. p59. and Soils & Crops Workshop 2006, University of Saskatchewan, March, 2006. Saskatoon, SK (poster abstract)

Re-cropping 11 Months After Everest (flucarbazone-sodium) Application. **K.L. Sapsford**, **F.A. Holm**, A. Irvine and B. Schilling. Crop Development Centre, University of Saskatchewan; Arysta Life Science, Saskatoon, SK. Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK. March 2-3, 2006. (poster abstract).

Interactions of Residual ALS Inhibiting Herbicides Bryce G.L. Geisel, Jeff J. Schoenau, Eric N. Johnson, **Kenneth L. Sapsford** and **Frederick A. Holm**. Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK. March 2-3, 2006. and Proceedings, Annual Meeting of the Western Society of Weed Science, Reno, NV. March, 2006. (poster abstract)

Impact of In-crop and Soil Residual Herbicides on Nodulation and Effective N-fixation in Field Pea (*Pisum sativum* L.) and Chickpea (*Cicer arietinum* L). Angela Taylor, Fran Walley, **Rick Holm**, **Ken Sapsford**, and Newton Lupwayi. Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK. March 2-3, 2006.

Sulfentrazone / Isoxaflutole Combinations for Weed Control in Chickpea. E.N. Johnson, **K.L. Sapsford** and **F.A. Holm**. Proceedings, Annual Meeting of the Western Society of Weed Science, Reno, NV. March, 2006. (poster abstract)

Reducing Rates Of Sulfentrazone/Isoxaflutole Combinations For Weed Control In Chickpeas. Johnson, E.N.², **Sapsford, K.L.**¹ **Holm, F.A** and Blackshaw, R.E.³. ¹ Dept. of Plant Sciences, University of Saskatchewan, 51 Campus Dr., Saskatoon, SK. S7N 5A8; ^{2,3} Agriculture and Agri-Food Canada, Scott, SK and Lethbridge, AB. Proceedings, Sixth Canadian Pulse Research Conference, Saskatoon, SK. 1-3 November, 2006. (poster and two page summary)

Foxtail Barley (*Hordeum jubatum*) Control in Wheat and Flax. **K.L Sapsford** and **F.A. Holm**. Proceedings, Canadian Weed Science Society, Victoria, BC. 26-29 November, 2006. (Poster and abstract)

Effect Of Isoxaflutole Timing On Weed Control In Chickpea. Johnson, E.N., **K.L. Sapsford**, **F.A. Holm** and R.E. Blackshaw. Proceedings, Can. Soc. Weed Sci. annual conference, Victoria, BC. 26-29 November, 2006.

The Potential for PPO Inhibitor Herbicides to Control Broadleaf Weeds in Pulse Crops

E.N. Johnson, D.A. Ulrich, R.E. Blackshaw, W.E. May, **K.L. Sapsford**, and **F.A. Holm**. Proceedings, 6th Canadian Pulse Research Workshop, Saskatoon, SK. 01-03 November, 2006.

Technical Reports:

23-24 January, 2006. Arysta LifeScience Everest Technical Workshop, Victoria, BC

Reports by **K. Sapsford** and **R. Holm** on:

- Pre-emergence use pattern – efficacy
- Pre-emergence use pattern – tank-mixes
- Pre-emergence use pattern – Group 1 combinations
- Clearfield canola
- Flax
- First year crop rotations
- Emergency plantbacks
- Second year crop rotations

Tom Wolf¹, **Rick Holm**², Linda Hall³, and Rene Van Acker⁴. **2006. The Impact of Herbicide Mode of Action on Low-Drift Spray Effectiveness**. Final Report to Agriculture Development Fund, Saskatchewan Agriculture & Food. January, 2006. 47pp. ¹ Agriculture & Agri-Food Canada, Saskatoon, ² University of Saskatchewan, Saskatoon, ³ Alberta Agriculture, Food and Rural Development, Edmonton, ⁴ University of Manitoba, Winnipeg.

F.A. Holm, K. Sapsford, G. Stuber and T. Ife. 2006. Weed Control Research, 2005. A summary of weed research conducted in 2005 and distributed to funding agencies and appropriate extension personnel. 85 pp

Presentations & Field Tours

- August 3, 2006. Dr. B. Battur, Director, Plant Protection Research Institute, and B. Amarsanna, Lecturer, Mongolian State University of Agriculture, Ulaanbaatar, Mongolia, Dr. Len Juras, Dow AgroScience and Mr. Bill May, Agriculture & Agri-Food Canada. Tour weed management research sites. (Holm & Sapsford).
- August 4, 2006. Mr. Doug Richardson, Bayer CropScience. Tour herbicide research plots, Kernen Crop Research Farm. (Holm & Sapsford).
- August 24, 2006. Arysta LifeScience (3) and Federated Co-operatives Ltd. (3) staff tour of herbicide research plots, Kernen Crop Research Farm. (Holm & Sapsford).
- September 12, 2006. Mr. David Strilchuk, FMC – tour herbicide desiccation, industrial hemp and other trials at Kernen Crop Research Farm. (Holm & Sapsford).
- Nov 22 – 23, 2006. Presentation at Direct Seeding meeting in Edmonton ~ 180 (Sapsford)

- Jan 16 – 17, 2007. Presentation at Agronomy update – Lethbridge ~450 (Sapsford)

Newspaper and magazine articles

- Top Crop Manager – Broadleaf Weed Control in Chickpea shows Potential (Sapsford).
- Top Crop Manager – Herbicide residues are Possible, but Rare (Sapsford).
- Country Guide – Long fall provides weed control window (Sapsford).
- Top Crop Manager – What to re-Crop after Everest (Sapsford).
- Grainews – Roundleaf mallow Control (Sapsford).

Technical Committees and Support to Sask Agriculture & Food:

- Member, Weed Sub-council, Sask. Advisory Council on Soils and Agronomy. 2006. (F.A. Holm and K.L. Sapsford).
- Mar 27 – 29 Member of Saskatchewan delegation to Minor Use Priority Setting Meeting – Ottawa (Sapsford).
- April 5, 2006 - Assist SSCA in agenda setting for 2007 annual conference (Sapsford)
- April 6, 2006 - One day Research Technician Training for AgriArm Managers (Sapsford)
- July 5 & 6, 2006 - Crop Diagnostic Tour, Saskatoon ~200 participants. (Sapsford)
- Nov 1 – 3, 2006 - Help Organize 6th Canadian Pulse Crop Research Workshop, Saskatoon (Sapsford)
- Nov 27 – 29, 2006 - Help organize Canadian Weed Science Society annual meeting (Sapsford)
- Jan 8 – 11, 2007 - Work at Plant Sciences booth at Crop Production Show. (Sapsford & Holm)

2007-08

Refereed Journal Articles:

J.T. O'Donovan, K.N. Harker, G.W. Clayton, L.M. Hall, J. Cathcart, **K.L. Sapsford**, **F.A. Holm** and K. Hacault. 2007. **Volunteer Barley Interference in Spring Wheat Grown in a Zero-Tillage System**. *Weed Science* 2007 55:70-74

K.N. Harker, G.W. Clayton, R.E. Blackshaw, J.T. O'Donovan, E.N. Johnson, Y. Gan, **F.A. Holm**, **K.L. Sapsford**, R.B. Irvine and R.C. Van Acker. 2006. Persistence of **Glyphosate-Resistant Canola in Western Canadian Cropping Systems**. *Agronomy Journal* 98:107-119 (2006)

G.L. Graham, G. Peng, K.L. Bailey and **F.A. Holm**. 2007. **Effect of plant stage, *Colletotrichum truncatum* dose, and use of herbicide on control of *Matricaria perforata***. *BioControl* 52:573–589.

Research Posters presented:

Impact of residual herbicides on nitrogen fixation and yield of pulse crops.

Sapsford, K., F. Walley, A. Taylor, **R. Holm** and N. Lupwayi. 2007 Saskatchewan Soil Conservation Association Annual Meeting, Feb 14, Saskatoon, SK.

Tillage and Phosphorus Availability. Jeff J. Schoenau, D. Adderley, **R. Holm**, C.

Baan, T. King, M. Grevers, P. Qian, G. Lafond, A. Johnston, A. Moulin.

Proceedings, Soils & Crops Workshop, Saskatoon, SK. March 1-2, 2007.

Effect of Timing of Isoxaflutole Application on Weed Control In Desi Chickpea (*Cicer arietinum*). E.N. Johnson, D.J. Ulrich, R.E. Blackshaw, **K.L. Sapsford**,

F.A. Holm. Proceedings, Soils & Crops Workshop, University of Saskatchewan, March 1-2, 2007. (poster and abstract).

Foxtail Barley (*Hordeum jubatum*) Control in Wheat and Flax. **K.L. Sapsford**

and **F.A. Holm**. Proceedings, Canadian Weed Science Society, Victoria, BC.

Soils & Crops Workshop, University of Saskatchewan, March 1-2, 2007. (Poster and abstract)

Interaction of imazamox-bentazon tank-mixes in dry beans (*Phaseolus vulgaris*). 2007. E.N. Johnson, D. Ulrich, D.J. Downs, **F.A. Holm**, **K.L.**

Sapsford, R.E. Blackshaw, J.R. Moyer, T.J. Hogg, and Y. Gan. Proceedings, Canadian Weed Science Society annual conference, Mont Tremblant, QC. P 84. (poster abstract).

Conference Presentations:

The relative competition of popular canola hybrids. 2007. K.N. Harker, J.T.

O'Donovan, G.W. Clayton, R.E. Blackshaw, S. Brandt, E.N. Johnson, **F.A. Holm**, and **K.L. Sapsford**. Proceedings, Canadian Weed Science Society annual conference, Mont Tremblant, QC. P 78. (oral presentation abstract).

Efficacy of broadleaf weed control with flucarbazone-sodium. 2007. E.N.

Johnson, **K.L. Sapsford**, **F.A. Holm**, B.S. Schilling and, W.E. May. Proceedings, Canadian Weed Science Society annual conference, Mont Tremblant, QC. P 79. (oral presentation abstract).

Impact of pre-and split applications of flucarbazone-sodium on grass weed control and spring wheat (*Triticum aestivum*) yield. 2007. **K.L. Sapsford**, **F.A.**

Holm, and E.N. Johnson. Proceedings, Canadian Weed Science Society annual conference, Mont Tremblant, QC. P81. (oral presentation abstract).

Group 2 Herbicide Carryover and Interaction Risk Management in Canadian

Soils. 2008. Jeff Schoenau¹, Bryce Geisel¹, **Rick Holm**¹, Eric Johnson² and Anna

Szmigielski¹. ¹University of Saskatchewan, Saskatoon, SK S7N 5A8, ²Agriculture and Agri-Food Canada Scott Experimental Farm, Scott, SK S0K 4A0. Proceedings, 2008 Canadian Forage Seed Association Annual Meeting, Brandon, MB. January, 2008.

Technical Reports:

Minor Use Registration Screening Reports for 2007

Johnson, E.N.¹, Ulrich, D.¹, Holm, F.A.², Sapsford, K.², May, W.³, and Nybo, B.⁴
Hrynewich, B.¹, Schell, H.¹, Gampe, C.¹, Stuber, G.², Willoughby, O.³, and Sluth, D.⁴

¹Agriculture and Agri-Food Canada, Scott, SK, Canada

²University of Saskatchewan, Saskatoon, SK, Canada

³Agriculture and Agri-Food Canada, Indian Head, SK, Canada

⁴Wheatlands Conservation Group, Swift Current, SK, Canada

F.A. Holm, K. Sapsford, G. Stuber and T. Ife. 2007. **Weed Control Research, 2006**. A summary of weed research conducted in 2006 and distributed to funding agencies and appropriate extension personnel. 82 pp

Presentations & Field Tours

Ken Sapsford Extension activities Feb. 2007 to Jan. 2008 and approximate attendance.

Feb 14	Saskatchewan Soil Conservation Association – Herbicide effect on nodulation – 300
Feb 27 & 28	Arysta telepanel – Discussion on Everest – 70 SWP (Viterro) staff update
Mar 1 & 2	Soils & Crops Workshop – Poster on Foxtail Barley Control and Poster on IFT/SFT for weed control in Chickpea
Mar 20	Cargill Regina - Problem Weeds and Promising Herbicides - 50
Mar. 21	Heartland Agro Regina - Problem Weeds and Promising Herbicides - 60
Jul 4,5 & 6	Diagnostic School U of S – Herbicide Matrix – 60/day
July 10	Weed Tour Saskatoon - 40
July 12	Swift Current Field Day – 80
Nov 12-14	Participated in Monsanto Academic Workshop in St. Louis
Nov 29	CWSS annual conference - Impact of Pre- and Split Applications of Flucarbazone-sodium on Grass Weed Control and Spring Wheat (<i>Triticum aestivum</i>) Yield. - 25
Dec. 7	SSCA Crop Advisors Workshop - Weed Control Research Update - 150
Jan 8	Crop Production Show – Work in booth for Dept of Plant Sc.
Jan 18	Provincial minor use priority setting meeting
Jan 21 – 23	Arysta meeting presentations: • Impact of Pre- and Split Applications of Flucarbazone-sodium • Everest split applications with group 1 graminicide • Foxtail barley control with Everest • Wheat variety tolerance to Everest • Rotational crops following Everest

- Nitrogen use by wild oat
- Plant growth regulator trial results
- Crop tolerance to Everest when mixed with EC formulations and different adjuvants

Jan 30 & 31 Farm Tech in Edmonton – Problem Weeds & Promising Herbicides

Newspaper and magazine articles quoting K. Sapsford on results of research projects.

Country Guide – Timing of Burn Down Application – Apr 2007

Grain News – Dandelion – get them before they get you – April 2007

Western Producer – Dandelion Control – Sept 17, 2007

Grain News – Winter annual weed control – Sept 12, 2007

Country Guide – Weed control starts in the Fall – Oct 2007

Top Crop Manager - Pre-seed burnoff research could offer extended grassy weed control - 2008

Top Crop Manager - Flexible strategies for foxtail barley control - 2008

Technical Committees and Support to Sask Agriculture & Food:

- Member, Weed Sub-council, Sask. Advisory Council on Soils and Agronomy. 2007. (F.A. Holm and K.L. Sapsford).
- Jan 7 – 12, 2008 - Work at Plant Sciences booth at Crop Production Show. (Sapsford & Holm)
- Participation in provincial Minor Use Registration Priority Setting (Sapsford & Holm) in January 2007. Sapsford participated in the January, 2008 and January 2009 provincial meetings. Sapsford attended the National Priority Setting Meeting in Ottawa in March 2007 and will attend the National Priority Setting Meeting in Ottawa in March, 2009.

Farm and Trade Shows

Crop Production Show – 09 January, 2008.

2008-09

Refereed Journal Articles:

Submitted:

Development and application of a lab bioassay for sulfentrazone detection in soil. Ana M. Szmigielski, Jeff J. Schoenau, Eric N. Johnson, **Frederick A. Holm** and Ken L. Sapsford. (Submitted to Weed Technology)

Accepted:

The history of herbicide use for weed management on the prairies

F.A. (Rick) Holm and Eric N. Johnson. Prairie Soil and Crop. Issue #2, 2009.

Saskatchewan Soil Conservation Association, Indian Head, SK. Accepted January, 2009)

Published:**Interactions of ALS-Inhibiting Herbicide Residues in Three Prairie Soils.**

2008. Bryce G.L. Geisel, Jeff J. Schoenau, Frederick A. Holm, and Eric N. Johnson. *Weed Science*, 56:4 pp. 624-627.

Research Posters presented:

Impact of pre-and split applications of flucarbazone-sodium on grass weed control and spring wheat (*Triticum aestivum*) yield. 2007. K.L. Sapsford, F.A. Holm, and E.N. Johnson. *Proceedings, Western Society of Weed Science*, Anaheim, CA. March, 2008.

Timing of spring application for winter annual weed control. 2008. K.L. Sapsford, F.A. Holm, E.N. Johnson and G. Clezy. *Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK.* March, 2008. (poster abstract)

Winter annual cleavers (*Galium aparine*) control. 2008. K.L. Sapsford and F.A. Holm. *Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK.* March, 2008. (poster abstract)

Development and application of a bioassay for detection of sulfentrazone in soil. 2008. Anna M. Szmigielski, Jeff J. Schoenau, Eric Johnson, **Ken Sapsford** and **Rick Holm**. *Proceedings, Soils & Crops Workshop, University of Saskatchewan, Saskatoon, SK.* March, 2008. (poster abstract)

The Relative Competition of Canola Versus Small Grain Cereals. 2008. Kenneth Harker¹, John O'Donovan¹, George Clayton¹, Robert Blackshaw¹, Stewart Brandt¹, Eric Johnson¹, **Rick Holm²**, **Ken Sapsford²**; ¹Agriculture & Agri-Food Canada, Lacombe, Alberta, Canada; ²University of Saskatchewan, Saskatoon, Saskatchewan, Canada. *Proceedings, 5th International Weed Science Congress, Vancouver, BC.* June, 2008.

Glyphosate-Resistant Wheat and Canola Systems: Volunteer Crop Persistence. 2008. Robert Blackshaw¹, Ken Harker¹, George Clayton¹, John O'Donovan¹, Eric Johnson¹, Yantai Gan¹, **Rick Holm²**, **Ken Sapsford²**, Bryon Irvine¹, Rene Van Acker³; ¹Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada; ²University of Saskatchewan, Saskatoon, Saskatchewan, Canada; ³University of Guelph, Guelph, Ontario, Canada. *Proceedings, 5th International Weed Science Congress, Vancouver, BC.* June, 2008.

Fall- vs Spring-Applied Sulfentrazone for Weed Management in Chickpea (*Cicer arientum*). 2008. Eric Johnson¹, Robert Blackshaw¹, **Ken Sapsford²**, **Frederick Holm²**; Agriculture and Agri-Food Canada, Scott, SK, Canada; ²University of Saskatchewan, Saskatoon, SK, Canada. *Proceedings, 5th International Weed Science Congress, Vancouver, BC.* June, 2008.

Glyphosate-resistant wheat and canola systems: volunteer crop persistence. 2008. Blackshaw, Harker, Clayton, O'Donovan, Johnson, Gan, **Holm, Sapsford**, Irvine and Van Acker. 5th International Weed Science Congress, Vancouver, BC. (poster abstract).

Holm, F.A., Sapsford, K.L. and Vandenberg, A. **Expanding Herbicide Options for Broad-leaved Weed Control in Lentil (*Lens culinaris* Medik.).** Proceedings, 7th Canadian Pulse Research Workshop, Winnipeg, MB. November, 2008. (Poster Abstract)

Marles, M.A.S. **Holm, F.A.** and Warkentin, T.D. **Allelopathic Attributes Of Field Pea.** Proceedings, 7th Canadian Pulse Research Workshop, Winnipeg, MB. November, 2008. (Poster Abstract)

Johnson, E.N.1, Ulrich, D.J., Blackshaw, R.E., May, W.E., Gan, Y.T., **Sapsford, K.L., Holm, F.A.**, and Oostlander, M. **Advances In Chemical Weed Control In Pulse Crops.** Proceedings, 7th Canadian Pulse Research Workshop, Winnipeg, MB. November, 2008. (Abstract)

Tar'an, B*, **Holm, F.A.**, Banniza, S., **Sapsford, K.**, Warkentin, T. Vandenberg, A., Ife, S. and Barlow, B. **Effects of Herbicide Applications on Ascochyta Blight Disease in Chickpea.** Proceedings, 7th Canadian Pulse Research Workshop, Winnipeg, MB. November, 2008. (Poster Abstract)

Johnson, E.N., Blackshaw, R.E., Wolf, T.M., Caldwell, B.C., **Holm, F.A.**, and **Sapsford, K.L.** **Kixor™ Technology in Western Canada.** 62nd Canadian Weed Science Society annual conference, Banff, AB. November, 2008. (oral presentation)

K.L. Sapsford, F.A. Holm, E.N. Johnson, R. Neyedley and S. Dilk. Evaluating herbicides for control of Canada fleabane (*Conyza Canadensis* L. Cronq.) in Western Canada. 62nd Canadian Weed Science Society annual conference, Banff, AB. November, 2008. (poster presentation).

A. Legere, A.G. Thomas, J.Y. Leeson, F.C. Stevenson, **F.A. Holm**, B. Gradin and D. Kratchmer. **How to use crops to manage weeds: six IWM systems for the moist mixed grassland ecoregion.** 62nd Canadian Weed Science Society annual conference, Banff, AB. November, 2008. (poster presentation).

A.M. Szmigielski, J.J. Schoenau, E.N. Johnson, **F.A. Holm** and **K.L. Sapsford.** **Development and application of a lab bioassay for sulfentrazone detection in soil.** 62nd Canadian Weed Science Society annual conference, Banff, AB. November, 2008. (oral presentation)

Western Society of Weed Science – Poster – Herbicides for Control of Mare's tail in Western Canada. Submitted - **Sapsford, Holm, Johnson, Dilk & Neyedley**. (March, 2009)

Technical Reports:

Weed Control Research – 2007. F.A. Holm, K. Sapsford, G. Stuber and T. Ife. Dept. of Plant Sciences, University of Saskatchewan. 121 pp. Winter, 2008.

Weed Control Research – 2008. F.A. Holm, K. Sapsford, G. Stuber and A. Gravelle. Dept. of Plant Sciences, University of Saskatchewan. 73 pp. January, 2009.

Presentations & Field Tours (approx. attendance)

July 3, 4 and 8, 2008. (**Holm & Sapsford**) Plan and resource a herbicide symptomology crop/weed/herbicide matrix at the Kernen Crop Research Farm for the 2008 Crop Diagnostic Schools (July 3 & 4 – Saskatchewan Crop Insurance, July 8 – Federated Co-operatives and Co-op Retail agronomists). A 2 hour presentation each day. Total attendance ~ 120 people.

July 22, 2008. (Holm) IHARF Crop Management Field Day, Indian Head, SK. Presentation on long-term management of Canada thistle (30 minutes x four groups). Total audience approximately 80 people.

Extension activities February, 2008 to March, 2009 and approximate attendance.

Feb 12&13, 2008	Saskatchewan Soil Conservation Association – Posters - Winter annual Cleavers Control & Timing of Winter Annual Weed Control – 330 producers. (Sapsford & Holm)
Feb 28 & 29, 2008	Soils and Crops Workshop - Posters - Winter Annual Cleavers Control & Timing of Winter Annual Weed Control. (Sapsford & Holm)
March 4, 2008	JRI Agronomists meeting – Presentation – Problem Weeds and Promising Herbicides – 80 Agronomists (Sapsford)
March 13, 2008	Oct. 30, 2008 Provincial Weed Council meeting – Presentation - Perennial Broadleaf Weed Control Initiative – Dandelion Control (Sapsford).
April 17, 2008.	(Holm) Update on New Herbicides and Minor Use Registration Program to SK Ministry of Agriculture Extension Staff, Provincial Specialists and Agri-Arm Site Managers. Saskatoon, SK.
Dec 4, 2008	SSCA Crop Advisors Workshop – Presentation – Glyphosate Resistance and control of Canada Fleabane (Sapsford)
Jan 27, 2008	Arysta Research Meeting – Four presentations – (Sapsford) Deploy Ratios

- ARY-0548 Rates and Adjuvants
 PrePare fb clodinafop
 PrePare fb Axial
- Feb 25 & 26, 2009 Soils & Crops Workshop – 2 Posters Submitted by **Sapsford & Holm**
 Herbicides for Control of Canada Fleabane in Western Canada
 Herbicides for Control of Group 2 resistant Kochia in Wheat
- Feb 12, 2009 Sask Soil Conservation Association – Presentation – Early vs Late
 Winter Annual Control – Scheduled (**Holm & Sapsford**)
- March 5, 2009 Scott Research Update – Presentation - Perennial Broadleaf Weed
 Control Initiative – Dandelion Control – Scheduled (**Sapsford**)

Dept. Visits & Tours (approx. attendance)

July 9, 2008. (**Holm**) Dr. Hossein Ghadiri, Professor, Dept of Agronomy, Shiraz University, Shiraz Iran. Tour Plant Sciences / CDC facilities, discuss graduate student visits and possible visiting scientist visit in 2009.

July 7, 2008. (**Holm**) Dr. Anis Rahman, Team Leader, Plant Protection, AgResearch Limited. Ruakura Research Centre, Hamilton, New Zealand. Tour Plant Sciences / CDC.

News & magazine articles that K. Sapsford has been quoted in 2008-09.

Top Crop Manager -Pre-seed burnoff research could offer extended grassy weed control
 Feb Grainews – Early control of winter annuals, Group 2 resistant Kochia Control and
 Winter Annual Cleavers Control.

Feb Western Producer– Early control of winter annuals, Group 2 resistant Kochia Control
 and Winter Annual Cleavers Control.

Growing Knowledge bulletin – Alert – Post Seed Burnoff

Growing Knowledge bulletin – Alert – Fall Control of Dandelions

Growing Knowledge - Agronomic Spotlight – Post-harvest weed control

Growing Knowledge – Weed Science Corner: foxtail barley

Top Crop Manager – Seed peas into clean ground

Top Crop manager – Kochia control

Top Crop manager – Glyphosate and Canada fleabane control

Top Crop Manager – Pre-seed burn-down timing for winter annual weeds

Quoting Holm

January 10, 2008 – Western Producer interview – glyphosate resistance and zero-till.

February 25, 2008. Grain News interview – Water Quality & Herbicide Efficacy

April, 2008. Country Guide magazine – interview on Economic Weed Thresholds.

May 07, 2008 – Western Producer – interview regarding Water Quality and Herbicides

Farm and Trade Shows

Crop Production Show – 12 January, 2009 (Holm & Sapsford).

(j) Other – Financial Summary

An official statement of revenue and expenses for this grant will be provided by the University's Research Accounts office. The following Table summarizes the total income generated by our program during the project reporting period.

Growing Season	Source of Funds & Amount (\$)		Total (\$)
	Government	Industry	
2004	94,519	142,223	236,742
2005	107,414	188,782	296,196
2006	136,600	168,200	304,800
2007	114,646	145,794	260,440
2008	102,016	211,145	313,161
TOTALS	555,195	856,144	1,411,339

Averaged over the four years, 39% of the funding has been obtained from government sources and 61% from industry (herbicide manufacturers and producer groups). Current indications are that we should be able to maintain this level of industry funding for at least the next few years.

